

WHAT IS CLAIMED IS:

1. A plasma processing apparatus for supplying microwaves into a process chamber so as to generate plasma, to thereby treat an object to be processed with the plasma;

5 wherein the process chamber has a top plate which is disposed opposite to the object to be processed, through the medium of a region for generating the plasma; and the top plate has at least one antenna which is disposed so that the antenna penetrates the top 10 plate into the inside of the process chamber.

15 2. A plasma processing apparatus according to claim 1, wherein the antenna comprises a voltage-drawing rod for drawing a voltage from a waveguide or resonator disposed outside of the process chamber; and an insulating material surrounding the voltage-drawing rod.

20 3. A plasma processing apparatus according to claim 1, wherein at least one antenna is disposed in the process chamber, so as to provide a linear and/or curved line.

25 4. A plasma processing apparatus according to claim 2, wherein the position of the voltage drawing of the voltage-drawing rod 17 in the waveguide corresponds to  $\{(l+2m)/2\}\lambda_g \pm (1/4)\lambda_g$  ( $\lambda_g$ : guide wavelength; m: integer) from the terminal of the waveguide.

30 5. A plasma processing apparatus according to claim 2, wherein the thickness or diameter of the voltage-drawing rod disposed in the process chamber is changed along the propagation direction of the microwaves.

35 6. A plasma processing apparatus according to claim 2, which has a tuner for changing the degree of the protrusion of the voltage-drawing rod into the waveguide or resonator.

7. A plasma processing apparatus according to claim 2, which has a mechanism for moving the voltage-drawing rod per se so that the coupling between the

plasma and the waveguide or resonator is variable.

8. A plasma processing apparatus according to claim 2, wherein an insulating fluid is circulated between the voltage-drawing rod and the insulating material.

5 9. A plasma processing apparatus according to claim 2, which has a mechanism for variably changing the distance between the top plate and the voltage-drawing rod.

10 10. A plasma processing apparatus according to claim 1, wherein a measuring device is disposed in at least one position of the top plate so as to monitor the state of the generated plasma.

15 11. A plasma processing apparatus according to claim 1, wherein the top plate has a plurality of holes for passing a gas to be supplied to the process chamber.

20 12. A plasma processing apparatus according to claim 1, wherein a susceptor for supporting the object to be processed is disposed in the process chamber, and a bias is applicable to the susceptor.

25 13. A plasma processing apparatus according to claim 1, wherein at least a portion of the ground line in the process chamber has an opening, and the plasma is generated due to the radiation of a microwave electric field from the opening toward the outside of the ground line.

30 14. A plasma processing apparatus for supplying microwaves into a process chamber so as to generate plasma, to thereby treat an object to be processed with the plasma;

35 wherein the process chamber comprises a top plate and a chamber wall for defining the process chamber; and the chamber wall has at least one antenna so that the antenna penetrates the chamber wall into the inside of the process chamber; and the antenna is disposed in the inside of the process chamber with respect to the top plate.

15. A plasma processing apparatus according to  
claim 14, wherein the antenna comprises a voltage-drawing  
rod for drawing a voltage from a waveguide or resonator  
disposed outside of the process chamber; and an  
5 insulating material surrounding the voltage-drawing rod.
16. A plasma processing apparatus according to  
claim 14, wherein at least one antenna is disposed in the  
process chamber, so as to provide a linear and/or curved  
line.
- 10 17. A plasma processing apparatus according to  
claim 15, wherein the position of the voltage drawing of  
the voltage-drawing rod 17 in the waveguide corresponds  
to  $\{(1+2m)/2\}\lambda_g \pm (1/4)\lambda_g$  ( $\lambda_g$ : guide wavelength; m:  
integer) from the terminal of the waveguide.
- 15 18. A plasma processing apparatus according to  
claim 2, wherein the thickness or diameter of the  
voltage-drawing rod disposed in the process chamber is  
changed along the propagation direction of the  
microwaves.
- 20 19. A plasma processing apparatus according to  
claim 15, which has a tuner for changing the degree of  
the protrusion of the voltage-drawing rod into the  
waveguide or resonator.
- 25 20. A plasma processing apparatus according to  
claim 15, which has a mechanism for moving the voltage-  
drawing rod per se so that the coupling between the  
plasma and the waveguide or resonator is variable.
- 30 21. A plasma processing apparatus according to  
claim 2, wherein an insulating fluid is circulated  
between the voltage-drawing rod and the insulating  
material.
- 35 22. A plasma processing apparatus according to  
claim 15, which has a mechanism for variably changing the  
distance between the top plate and the voltage-drawing  
rod.
23. A plasma processing apparatus according to  
claim 14, wherein a measuring device is disposed in at

least one position of the top plate so as to monitor the state of the generated plasma.

5        24. A plasma processing apparatus according to claim 14, wherein the top plate has a plurality of holes for passing a gas to be supplied to the process chamber.

25      25. A plasma processing apparatus according to claim 14, wherein a susceptor for supporting the object to be processed is disposed in the process chamber, and a bias is applicable to the susceptor.

10     26. A plasma processing apparatus according to claim 14, wherein at least a portion of the ground line in the process chamber has an opening, and the plasma is generated due to the radiation of microwave electric field from the opening toward the outside of the ground line.

15     27. A plasma processing apparatus for supplying microwave into a process chamber so as to generate plasma, to thereby treat an object to be processed with the plasma;

20                wherein the process chamber has a top plate which is disposed opposite to the object to be processed through the medium of a region for generating the plasma; and the top plate comprises a metal-based or silicon-based material.

25     28. A plasma processing apparatus according to claim 28, wherein the antenna comprises a voltage-drawing rod for drawing a voltage from a waveguide or resonator disposed outside of the process chamber; and an insulating material surrounding the voltage-drawing rod.

30     29. A plasma processing apparatus according to claim 28, wherein at least one antenna is disposed in the process chamber, so as to provide a linear and/or curved line.

35     30. A plasma processing apparatus according to claim 29, wherein the position of the voltage drawing of the voltage-drawing rod 17 in the waveguide corresponds to  $\{(1+2m)/2\}\lambda_g \pm (1/4)\lambda_g$  ( $\lambda_g$ : guide wavelength; m:

integer) from the terminal of the waveguide.

5 31 32. A plasma processing apparatus according to claim 29, wherein the thickness or diameter of the voltage-drawing rod disposed in the process chamber is changed along the propagation direction of the microwave.

32 33. A plasma processing apparatus according to claim 29, which has a tuner for changing the degree of the protrusion of the voltage-drawing rod into the waveguide or resonator.

10 33 34. A plasma processing apparatus according to claim 29, which has a mechanism for moving the voltage-drawing rod per se so that the coupling between the plasma and the waveguide or resonator is variable.

15 34 35. A plasma processing apparatus according to claim 29, wherein an insulating fluid is circulated between the voltage-drawing rod and the insulating material.

20 35 36. A plasma processing apparatus according to claim 29, which has a mechanism for variably changing the distance between the top plate and the voltage-drawing rod.

25 36 37. A plasma processing apparatus according to claim 28, wherein a measuring device is disposed in at least one position of the top plate so as to monitor the state of the generated plasma.

37 38. A plasma processing apparatus according to claim 28, wherein the top plate has a plurality of holes for passing a gas to be supplied to the process chamber.

30 38 39. A plasma processing apparatus according to claim 28, wherein a susceptor for supporting the object to be processed is disposed in the process chamber, and a bias is applicable to the susceptor.

35 39 40. A plasma processing apparatus according to claim 28, wherein at least a portion of the ground line in the process chamber has an opening, and the plasma is generated due to the radiation of microwave electric field from the opening toward the outside of the ground

line.